REMARKS

This Response responds to the Office Action dated January 8, 2007 in which the Examiner rejected claims 7 and 13 under 35 U.S.C. §102(b) and rejected claims 9-12 and 14 under 35 U.S.C. §103.

Applicants respectfully traverse the finality of the Office Action. Applicants respectfully point out that merely incorporating an allowable dependent claim into an independent claim does not introduce a "new" issue that necessitates a rejection. Therefore, Applicants respectfully request the Examiner withdraws the finality of the Office Action.

Claim 7 claims a method of manufacturing electronic parts, comprising the steps of first, providing a holding jig made of an elastic material, wherein at least one surface of the elastic material is adhesive. Next, a substrate on the is mounted holding jig by an adhesive strength of the surface of the elastic material. An element is mounted onto the substrate and the element is electrically connected to the substrate while the substrate is held on the surface of the elastic material. Ultrasonic waves are applied to a bonding portion at which the electric connection is performed while the substrate is held on the surface of the elastic material.

Through the method of the claimed invention a) manufacturing electronic parts, b) providing a holding jig made of an elastic material having at least one surface which is adhesive, c) mounting an element onto a substrate and electrically connecting the element to the substrate while the substrate is held on the surface of the elastic material and d) applying ultrasonic waves to a bonding portion at which the electric connection is performed, as claimed in claim 7, the claimed invention provides a method of manufacturing electronic parts which prevents the generation

of electrostatic charges. The prior art does not show, teach or suggest the invention as claimed in claim 7.

Claims 7 and 13 were rejected under 35 U.S.C. §102(b) as being anticipated by *Riemer* (U.S. Patent 4,583,042).

Applicants respectfully traverse the Examiner's rejection of the claims under 35 U.S.C. §102(b). The claims have been reviewed in light of the Office Action, and for reasons which will set forth below, Applicants respectfully request the Examiner withdraws the rejection to the claims and allows the claims to issue.

Riemer appears to disclose testing systems for testing the electrical continuity and/or integrity of conductive line segments on circuit boards. (Column 1, lines 8-10). Fig 1 shows a capacitance circuit board testing system, generally indicated at 10. As here shown, the testing system 10 includes a single shielded one-point probe 11 of conventional construction which may be shifted relative to the underlying circuit board 12 to be tested either manually or automatically by any suitable coordinate indexing mechanism (not shown) to permit electrical contact between the probe 11 and a successively presented series of n test points (where "n" is any whole integer, but, is commonly on the order of several hundred) on the circuit board 12 being tested where such n test points commonly comprise the end points on a plurality of conductive line segments 14. (Column 6, lines 6-18). Capacitance meter 16 is provided with a second terminal 18 coupled directly to a reference plane, generally indicated at 19, located on the backside of circuit board 12 for measuring capacitance in the particular line segment 14 undergoing test at any given instant of time. (Column 6, lines 29-34). To this end, the capacitance measuring system 10 a support 20 having a vacuum chamber 21 coupled to a suitable vacuum source such,

for example, as a conventional vacuum pump 22. Support 20 is provided with a plurality of vacuum bores 24 extending vertically through the support and registered with a corresponding plurality of through vacuum bores 25 extending vertically through a circuit or insulator board 26 having a conductive layer 28 formed on its upper surface. A conductive pliant sheet 29 formed, for example, of a conductive elastomer such as conductive rubber or rubber-like material and including a plurality of vertically extending complementary through vacuum bores 30 is positioned on the conductive layer 28 on circuit board 26 with the through vacuum bores 24, 25 and 30 in support 20, board 26 and conductive elastomer 29, respectively, aligned. The entire assembly is held in tightly clamped sandwich-like configuration by means of an upper double-sided circuit board 31 having upper and lower spaced conductive layers 32, 34, respectively; with circuit board 31 being secured to support 20 by any suitable means such, for example, as threaded fasteners or the like. (Column 6, line 51 to column 7, line 6).

Thus, *Riemer* merely discloses <u>testing</u> electrical continuity and/or integrity of conductive line segments on circuit boards. Nothing in *Riemer* shows, teaches or suggests a method of <u>manufacturing</u> electronic parts as claimed in claim 7. Rather, *Riemer* is merely directed to <u>testing</u> parts.

Additionally, *Riemer* merely discloses mounting a circuit board 26 on a support 20 and holding it thereon by a conventional vacuum system including a vacuum pump 22 and a clamping mechanism such as threaded fasteners or the like. Thus, nothing in *Riemer* shows, teaches or suggests mounting a substrate by an adhesive strength of an adhesive surface of an elastic material as claimed in claim 7.

Rather, *Riemer* teaches away from the claimed invention and holds the circuit board 12 via a vacuum system and pump 22 along with threaded fasteners.

Also, *Riemer* merely discloses a plurality of a conductive line segments mounted on a circuit board 12. Nothing in *Riemer* shows, teaches or suggests electrically connecting an element to a substrate while the substrate is held on the surface of an elastic material as claimed in claim 7. Rather, *Riemer* only discloses that the circuit board 12 is provided with conductive line segments 14 (i.e., the line segments 14 are <u>not</u> mounted on the substrate while the substrate is held on the elastic surface and the line segments are <u>not</u> electrically connected to the substrate while held on the adhesive surface of the elastic material).

Finally, *Riemer* merely discloses measuring capacitance of a particular line segment 14 undergoing tests by a capacitance meter 16. Nothing in *Riemer* shows, teaches or suggests applying ultrasonic waves to a bonding portion as claimed in claim 7. Rather, *Riemer* only discloses measuring capacitance of a particular line segment 14 undergoing tests.

Attached to this response are four (4) excerpts from the Internet describing wire bonding. Applicants respectfully submit that wire bonding and measuring capacitance are two different and distinct actions.

Since nothing in *Riemer* shows, teaches or suggests a) a method of manufacturing electronic parts, b) mounting a substrate on a holding jig by an adhesive strength of a surface of an elastic material, c) mounting an element onto a substrate and electrically connecting the element to the substrate while the substrate is held on the surface of the elastic material and d) applying ultrasonic waves to a

bonding portion as claimed in claim 7, Applicants respectfully request the Examiner withdraws the rejection to claim 7 under 35 U.S.C. §102(b).

Claim 13 depends from claim 7 and recites additional features. Applicants respectfully submit that claim 13 would not have been anticipated by *Riemer* within the meaning of 35 U.S.C. §102(b) at least for the reasons as set forth above. Therefore, Applicants respectfully request the Examiner withdraws the rejection to claim 13 under 35 U.S.C. §102(b).

Claims 9-12 and 14 were rejected under 35 U.S.C. §103 as being unpatentable over *Riemer* in view of *Oehmke* (U.S. Patent 4,098,945).

Applicants respectfully traverse the Examiner's rejection of the claims under 35 U.S.C. §103. The claims have been reviewed in light of the Office Action, and for reasons which will be set forth below, Applicants respectfully request the Examiner withdraws the rejection to the claims and allows the claims to issue.

As discussed above, since nothing in *Riemer* shows, teaches or suggests the primary features as claimed in claim 7, Applicants respectfully submit that the combination of the primary reference with the secondary reference to *Oehmke* would not overcome the deficiencies of the primary reference. Therefore, Applicants respectfully request the Examiner withdraws the rejection to claims 9-12 and 14 under 35 U.S.C. §103.

As discussed above, Applicants respectfully request the Examiner withdraws the finality of the Office Action.

Thus it now appears that the application is in condition for reconsideration and allowance. Reconsideration and allowance at an early date are respectfully requested. Should the Examiner find that the application is not now in condition for

allowance, Applicants respectfully request the Examiner enters this Amendment for purposes of appeal.

If for any reason the Examiner feels that the application is not now in condition for allowance, the Examiner is requested to contact, by telephone, the Applicants' undersigned attorney at the indicated telephone number to arrange for an interview to expedite the disposition of this case.

In the event that this paper is not timely filed within the currently set shortened statutory period, Applicants respectfully petition for an appropriate extension of time. The fees for such extension of time may be charged to Deposit Account No. 02-4800.

In the event that any additional fees are due with this paper, please charge our Deposit Account No. 02-4800.

Respectfully submitted,

BUCHANAN INGERSOLL & ROONEY PC

Date: May 7, 2007

By: Ellen Marcie Emas
Registration No. 32131

P.O. Box 1404
Alexandria, VA 22313-1404
703 836 6620

Basic Information

What is Wire Bonding?

A method used to attach a fine wire, usually 1 to 3 mils in diameter, from one connection pad to another, completing the electrical connection in an electronic device, is called Wire Bonding. The pads can be bond sites on the semiconductor chip or metallized bond sites on interconnection substrates. Semiconductor die can also be wire bonded to metal lead frames as is done in plastic encapsulated devices. The methods presently used to wire bond include thermocompression, ultrasonic and thermosonic.

Background

According to recent literature, 4x 10^12 wires are bonded every year in the world and most are used in the approximately 40 to 50 billion integrated circuits (ICs) produced. Other types of bonding technology such C4 (Controlled Collapsed Chip Connection or Flip Chip) or TAB (Tape Automated Bonding) also have been used in parallel with conventional wire bonding technology. Wire bonding continues to be popular and dominant in the field of bonding technologies in the industry.
In the past, a large proportion of all semiconductor-device field failures were caused by wire bonds and the number of known failure mechanism were quite limited. Through the improvement of bonding technology the reliability of wire bonds is increasing, as is our understanding of the failure modes, though they continue to plague new manufacturing lines.

Brief History of Wire Bonding

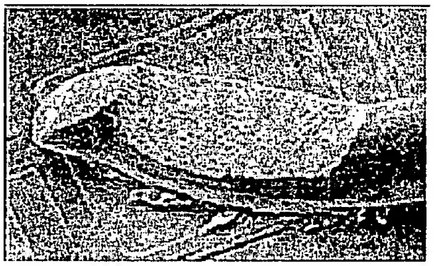
- 1957 - Bell Labs was the first to publish information regarding wire bonding *history of bonders*
- 1959 - J.W. Beams reported his characterization of metallic thin film strength.
- 1971 - Nowaskowski & Villela found three variations of power cycling tests.
- 1972 - Horsting publishes "Purple Plague and Gold Purity," describing contamination based void formation in intermetallic layers
- 1972 - Ravi & Philofsky: Machine for accelerated tests of various wires.
- 1973 - Ravi & Philofsky published a failure prediction model of thin films.
- 1973 - C.N. Adams developed a model for wire failure near ball bond.
- 1974 - G. Harman sited cause as manufacturing defects or environmental stresses.
- 1989 ~1991 - M. Pecht & A. Dasgupta models for wire flexture, pad & wire & substrate shear, and axial tension.
- 2000+ - Ramminger's work on under-wedge cracking.

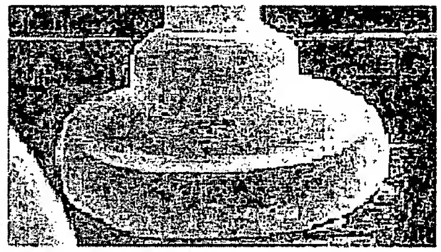
Back to Top.

How are They Formed?

There are basically two forms of wire bonds. They are Wedge bonds and Ball bonds. Recent study shows that about 90% of all electronic packages and assemblies are produced using ball bonds and about 10% are produced with wedge bonds. An increase in the use of ball bonding is expected as semiconductor devices increase in functionality and decrease in size causing smaller bond pads and

closer bond pad spacing.


Wedge Bond


Ball Bond

What are the Wire Materials?

The most widely used wire materials are Gold (Au) and Aluminum (Al) however, Silver (Ag) and Copper (Cu) are also used. Copper wire (ball bonding) has gained considerable attention due to its economic advantage and strong resistance to sweeping (leaning of the stress relief loop until it touches an adjacent bond wire). Bonding these wire materials to different pad materials creates different metallurgical systems called intermetallics. Gold was the original material used when wire bonding technology was developing. Aluminum has become popular due to its good electrical performance and lower cost. Gold wire can be bonded in the shape of a wedge or a ball. Ball bonds can be used in very tight spacing. Aluminum wire can only be wedge bonded and so is limited when spacing is tight.

Back to Top.

What are the Main Methods for Wire Bonding ?

- Thermocompression (Wedge-Ball)
Thermocompression bonding was first presented by Bell Laboratories in 1957 and extensively used until Ultrasonic bonding technology showed up in the mid 1960s. Thermocompression bonding requires a high-force on a surface with a high temperature; around 300°C. It provides excellent, reliable Al-Au bonds with flexibility in the bonding direction allowed. The wire material is Au but the pad can be Au or Aluminum.
-Ultrasonic (Wedge-Wedge Bonding)
Ultrasonic bonding is the most common bonding technology used for Al bond wires and is performed at ambient temperature. Bonding is formed as a wedge bond by pressure and vibrational energy.
-Thermosonic (Ball-Wedge Bonding)
Thermosonic bonding is used for Au wires and currently comprises about 90% of all wire bonding. It is done at temperatures of around 100°C to 240°C. Bonding is formed when the ultrasonic energy combines with the capillary technique of thermocompression bonding. Occasionally, it is used for Au wedge-wedge bonding, but mostly it is best suited for a ball-wedge bond.
A comparison of three types of wire bonding technologies is shown in table below.

Wirebonding	*Operating Temperature*	*Wire Materials*	*Pad Materials*	*Note*
Thermocompression	300-500°C	Au	Al, Au	High pressure, no ultrasonic energy
Ultrasonic	25°C	Au, Al	Al, Au	Low pressure in ultrasonic energy
Thermosonic	100-240°C	Au, Cu	Al, Au	Low pressure in ultrasonic energy

Back to Top.

What are the Typical Failure Mechanisms?

Common failures are:

- Cratering or peeling of a wire bond pad
- Wire bond fracture (leading to weak bonds or bond lifts)
- Inconsistent tails (which cause shorting with other bonds or traces on the surrounding circuitry)
- Poor welding (leading to weak bonds)
- Improper positioning on the bond pad (leading to shorts and bad welds)

How are They Evaluated?

Wire bonding evaluation criteria varies depending on the application requirements. Evaluation methods can be found in several published standards, but the most common standard is MIL-STD-883. It lists the following methods:

- Internal visual
- Destructive bond pull test
- Nondestructive bond pull test
- Ball bond shear test
- Constant acceleration
- Random vibration
- Mechanical shock
- Stabilization bake
- Moisture resistance

Note: Selection of the test method may vary depending on mission requirement.

Back to Top.

wire bonding

Science and Technology Dictionary

wire bonding ('wīr 'bänd·iŋ)

(*electricity*) Lead-covered tie used to connect two cable sheaths until a splice is permanently closed and covered.
(*electronics*) A method of connecting integrated-circuit chips to their substrate, using ultrasonic energy to weld very fine wires mechanically from metallized terminal pads along the periphery of the chip to corresponding bonding pads on the substrate. The attachment of very fine aluminum or gold wire (by thermal compression or ultrasonic welding) from metallized terminal pads along the periphery of an integrated circuit chip to corresponding bonding pads on the surface of the package leads.

---

more articles below...

Science and Technology Encyclopedia

Wire bonding

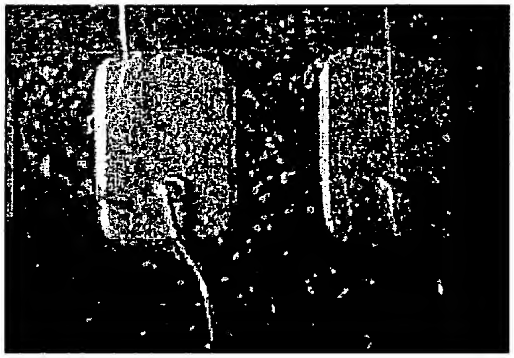
An interconnect technique widely used in microchip manufacturing to provide electrical continuity between the metal pads of an integrated circuit (IC) chip and the electrical leads of the package housing the chip. The two common methods of wire bonding are thermocompression and ultrasonic bonding. In these, a fine aluminum or gold wire is bonded at one end to the metal pad of the IC, and at the other to the electrical lead of the package. In ultrasonic bonding, the metallurgical bond is achieved through a combination of ultrasonic energy and pressure to break the few surface layers of the material and form the bond between the contamination-free surfaces. In thermocompression bonding, the metallurgical bond is formed by applying heat and pressure without melting. Thermocompression bonding has higher throughput and speed than ultrasonic bonding. *See also* Circuit (electronics); Electronic packaging; Integrated circuits; Ultrasonics.

---

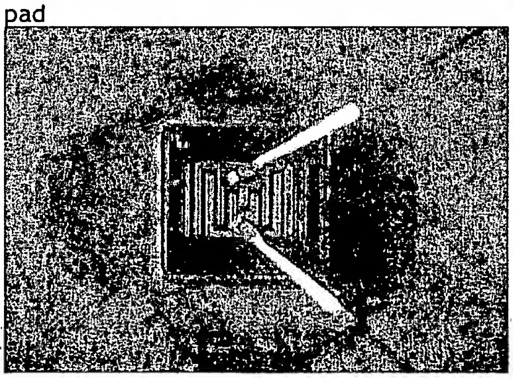
more articles below...

Wikipedia

wire bonding



Gold wire ball-bonded to a gold contact pad



Aluminium wires wedge-bonded to a KSY34 transistor die

The interconnection in a power package are made using thick aluminium wires (250 to 400 µm) wedge-bonded

Wire bonding is a method of making interconnections between a microchip and the outside world as part of semiconductor device fabrication.

The wire is generally made up of one of the following:

- Gold
- Aluminum
- Copper

Wire diameters start at 15 µm and can be up to several hundred micrometres for high-powered applications.

There are two main classes of wire bonding:

- Ball bonding

- Wedge bonding

Ball bonding usually is restricted to gold and copper wire and usually requires heat. Wedge bonding can use either gold or aluminium wire, with only the gold wire requiring heat.

In either type of wire bonding, the wire is attached at both ends using some combination of heat, pressure, and ultrasonic energy to make a weld.

Wire bonding is generally considered the most cost-effective and flexible interconnect technology, and is used to assemble the vast majority of semiconductor packages.

A: Introduction

A: Introduction | A: Guidelines | A: Background | A: References

Home

Up

Chapter A: Wire Bonding

A1. Level 1. Introduction of wirebonding technology

Print this section in .pdf format by clicking the link Print Section A1.

This guideline is concerned with wirebonding technology, which affords the fundamental knowledge and the practical applications to those who are using this technique as well as those who are interested in this technique. This guideline is divided into different levels according to reader' s requirements.

A1.1 What is wirebonding

Wirebonding is an electrical interconnection technique using thin wire and a combination of heat, pressure and/or ultrasonic energy. Wirebonding is a solid phase welding process, where the two metallic materials (wire and pad surface) are brought into intimate contact. Once the surfaces are in intimate contact, electron sharing or interdiffusion of atoms takes place, resulting in the formation of wirebond. In wirebonding process, bonding force can lead to material deformation, breaking up contamination layer and smoothing out surface asperity, which can be enhanced by the application of ultrasonic energy. Heat can accelerate Interatomic diffusion, thus the bond formation.

A1.1.1 Wirebonding processes

Wirebonding process begins by firmly attaching the backside of a chip to a chip carrier using either an organic conductive adhesive or a solder (Die Attach). The wires then are welded using a special bonding tool (capillary or wedge). Depending on bonding agent (heat and ultrasonic energy), the bonding process can be defined to three major processes: thermocompression bonding (T/C), ultrasonic bonding (U/S), and thermosonic bonding (T/S), as shown in Table A1.

Table A1. Three wirebonding processes.

Wirebonding	Pressure	Temperature	Ultrasonic energy	Wire	Pad
Thermocompression	High	300-500 °C	No	Au,	Al, Au
Ultrasonic	Low	25 °C	Yes	Au, Al	Al, Au
Thermosonic	Low	100-150 °C	Yes	Au	Al, Au

A1.1.2 Wirebond forms

There are two basic forms of wirebond: ball bond (Figure A1) and wedge bond (Figure A2), the corresponding bonding technique, bonding tool and materials are listed in Table A2. Currently, thermosonic gold ball bonding is the most widely used bonding technique, primarily because it is faster than ultrasonic aluminum bonding. Once the ball bond is made on the device, the wire may be moved in any direction without stress on the wire, which greatly facilitates automatic wire bonding, as the movement need only be in the *x* and *y* directions.

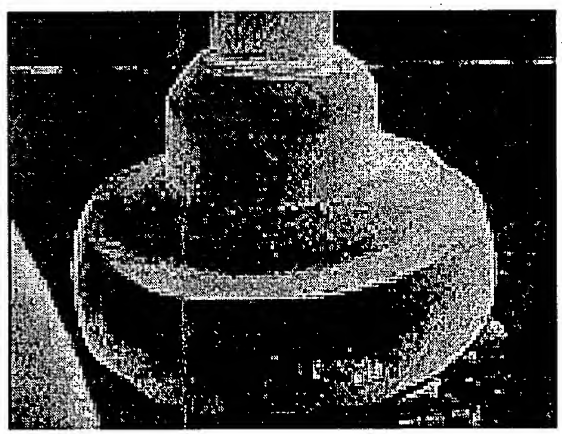


Figure A1. Ball bond (after APROVA Bonding tool).

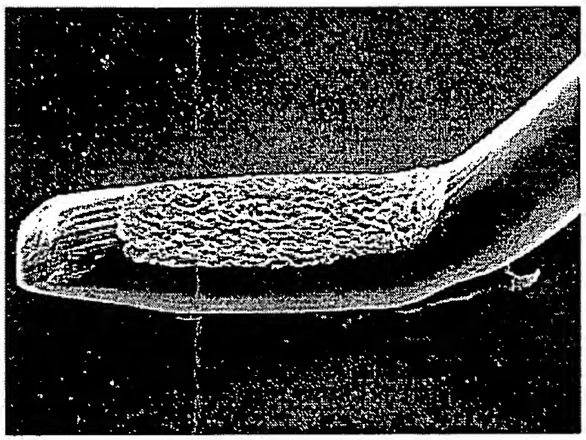


Figure A2. Wedge bond (after K&S Micro-Swiss).

Table A2. Wirebond formation.

Wirebond	Bonding technique	Bonding tool	Wire	Pad	Speed
Ball bond	T/C, T/S	Capillary	Au	Al, Au	10 wires/sec (T/S)
Wedge bond	T/S, U/S	Wedge	Au, Al	Al, Au	4 wires/sec

A1.3 History and applications

Wirebonding is the earliest technique of device assembly, whose first result was published by Bell Laboratories in 1957. Sine then, the technique has been extremely developed:

- Fully automatic machines have been developed for volume production.
- Bonding parameters can be precisely controlled; mechanical properties of wires can be highly reproduced.
- Bonding speed can reach 100-125 ms per each wire interconnection (two welds and a wire loop).
- Bond pitch of 50 mm and the consistent loop with less than 40 mm have been achieved.

Chapter A: Wire Bonding

A2. Level 2. Conclusions and guideline

Print this section in .pdf format by clicking the link Print Section A2.

A2.1 Wirebonding techniques

There are two basic wirebonding techniques that are used in thermocompression (T/C), thermosonic (T/S) or ultrasonic (U/S) bonding process: ball bonding and wedge bonding. Approximately 93% of all semiconductor packages are manufactured using ball bonding method, while wedge bonding is used to produce about 5% of all assembled packages.

A2.1.1 Ball bonding

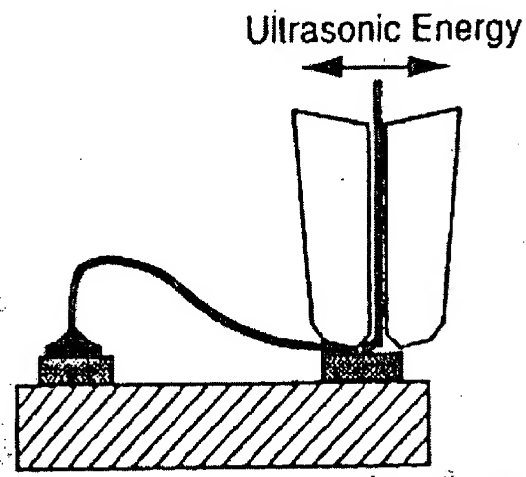


Figure A4. Ball bonding.

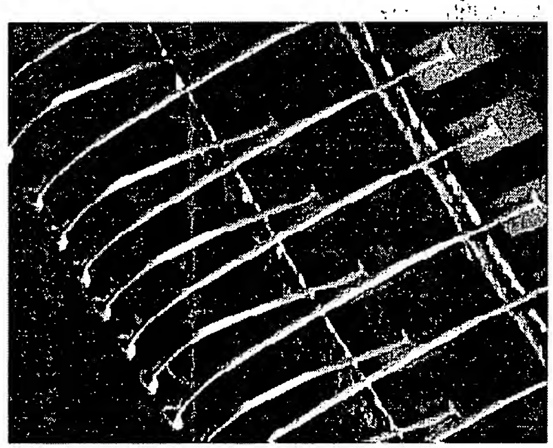


Figure A5. Application of ball bonding.

In this technique, wire is passed through a hollow capillary, and an electronic-flame-off system (EFO) is used to melt a small portion of the wire extending beneath the capillary. The surface tension of the molten metal from a spherical shape, or ball, as the wire material solidifies. The ball is pressed to the bonding pad on the die with sufficient force to cause plastic deformation and atomic interdiffusion of the wire and the underlying metallization, which ensure the intimate contact between the two metal surfaces and form the first bond (ball bond). The capillary is then raised and repositioned over the second bond site on the substrate, a precisely shaped wire connection called

a wire loop is thus created as the wire goes. Deforming the wire against the bonding pad makes the second bond (wedge bond or stitch bond), having a crescent or fishtail shape made by the imprint of the capillary' s outer geometry. Then the wire clamp is closed, and the capillary ascends once again, breaking the wire just above the wedge, an exact wire length is left for EFO to form a new ball to begin bonding the next wire. Ball bonding is generally used in thermocompression (T/C) or thermosonic bonding (T/S) process. This technique requires a high temperature raging from 100°C to 500°C depending on bonding process. Heat is generated during the manufacturing process either by a heated capillary feeding the wire or by a heated pedestal on which the assembly is placed or by both depending on the bonding purpose and materials. Relatively small gold wire (< 75 μm) is mostly used in this technique because of its easy deformation under pressure at elevated temperature, its resistance to oxide formation, and its ball formability during a flame-off or electronic discharge cutting process. Ball bonding is generally used in application where the pad pitch is greater than 100 μm. However, the application of the pitches with 50 μm has been reported.

A2.1.2 Wedge bonding

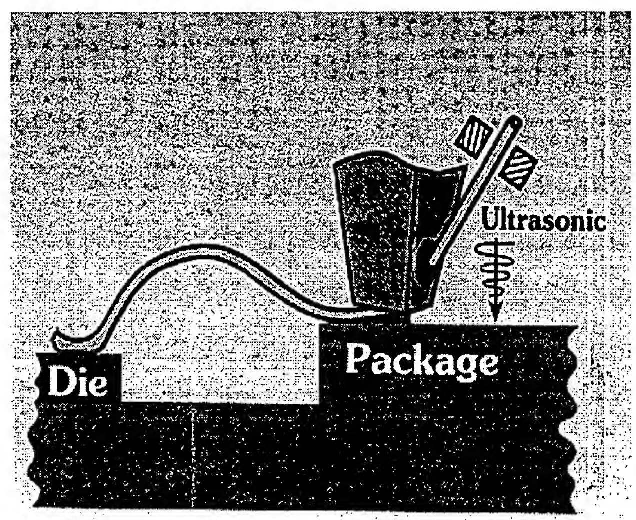


Figure A6. Ultrasonic wedge bonding (after K&S Micro-Swiss).